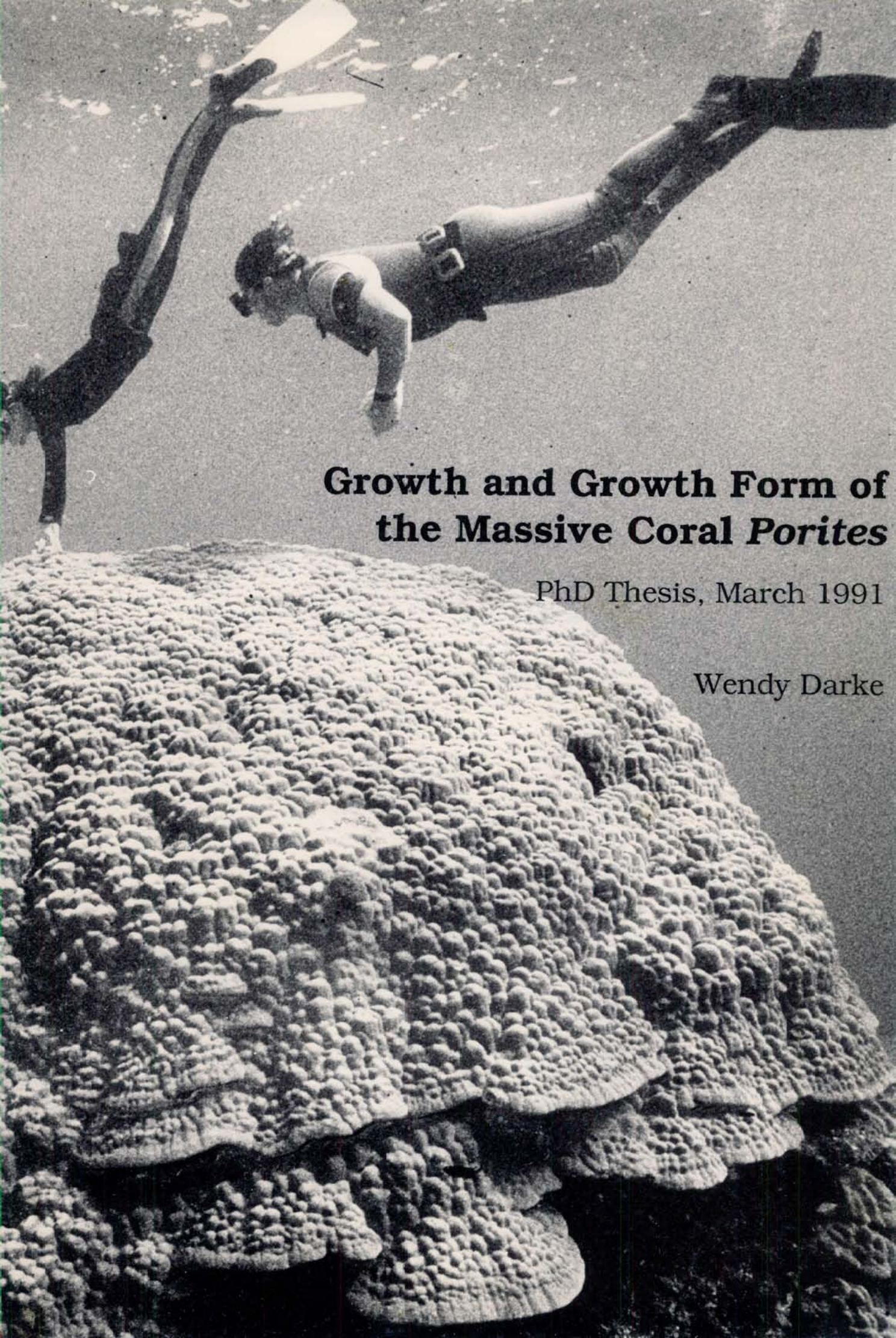

Growth and Growth Form of the Massive Coral *Porites*

PhD Thesis, March 1991

Wendy Darke

GROWTH AND GROWTH FORM OF THE MASSIVE CORAL *PORITES*

Thesis submitted by
Wendy Marilyn DARKE BSc(Hons) (Bristol, UK)
in March 1991

for the degree of Doctor of Philosophy in
the Marine Biology Department, School of Biological Sciences
at James Cook University of North Queensland

I, the undersigned, the author of this thesis, understand that James Cook University of North Queensland will make it available for use within the University Library and, by microfilm or other photographic means, allow access to users in other approved libraries. All users consulting this thesis will have to sign the following statement:

> "In consulting this thesis I agree not to copy or closely para-phrase it in whole or in part without the written consent of the author; and to make proper written acknowledgement for any assistance which I have obtained from it."

Beyond this, I do not wish to place any restriction on access to this thesis.

..... 25/3/91

(signature) (date)

ABSTRACT

Massive *Porites* colonies develop a bumpy growth surface as they increase in size. Development of a bumpy growth surface occurs when skeletal growth no longer provides the necessary increase in surface area to accommodate tissue growth. A massive *Porites* colony becomes bumpy when it reaches a critical size determined by the ratio of its tissue growth to its skeletal growth. This ratio also determines the degree of bumpiness which develops at the growth surface.

X-radiographs of skeletal slices cut from the vertical growth axis of massive *Porites* colonies display annual density banding and skeletal architecture associated with corallites, that is, skeleton deposited by individual polyps. Density bands outline former positions of the growth surface. Examination of X-radiographs of *Porites* shows that new corallites are initiated on, or towards, the summit of bumps, whilst older corallites are compressed and ultimately occluded at the bottom of valleys formed between bumps. X-radiographs show that it takes 4 to 7 years from the formation of a corallite to its occlusion. Polyps on the growth surface of a bumpy *Porites* colony must, therefore, be continually lost. All polyps are lost and replaced during a 4 to 7 year period. Consequently, tissue covering the growth surface of a massive *Porites* colony can be no older than 7 years, even though the colony may have been growing for several centuries.

Computer models designed to simulate growth of a massive *Porites* colony indicated that the growth form displayed by a *Porites* colony is determined by the ratio of tissue growth to skeletal growth. Models having a relatively faster tissue growth compared with skeletal growth developed a bumpy surface sooner, and the amount of bumpiness developed was greater, than for models having a relatively slower tissue growth compared with skeletal growth. Predictions from computer models accorded with observations and measurements made on actual colonies and on X-radiographs of skeletal slices cut from colonies. Thus, the ratio of tissue growth to skeletal growth determines important aspects of the growth form displayed by massive *Porites* colonies.

The ratio of tissue growth to skeletal growth was shown to significantly affect the rate of polyp loss and replacement in *Porites* colonies. The longevity of polyps is less in *Porites* colonies displaying a well developed bumpy growth surface than in colonies displaying a smoother growth surface. Hence, the age of polyps, and therefore the tissue, covering a bumpy growth surface is less than polyps and tissue covering a smooth growth surface.

Skeletal surface area in massive *Porites* colonies was shown to be a useful indicator of tissue biomass. Measurements of change in surface area of *Porites* colonies with increasing size show that the rate of tissue growth must decrease as the colony grows. Development of a bumpy growth surface alleviates this geometric restriction for only months to a couple of years. Development of a bumpy growth surface is an indication that tissue growth is becoming constrained by skeletal growth. Once a colony becomes bumpy, the tissue growth is almost totally constrained by the rate by skeletal extension.

Significant differences in growth and growth form characterised massive *Porites* colonies collected from different reef environments. Measurements made on the colonies suggested that differences in environmental conditions probably altered the ratio of tissue growth to skeletal growth and caused the colonies to grow in different ways. Differences in growth were reflected in the resulting growth form. Information about relative rates of tissue and skeletal growth within a massive *Porites* colony gained from observations and measurements of the growth form can be used to provide further information about coral growth and details of environmental conditions obtaining during growth.

CONTENTS

PLATES

FIGURES

Figure **Page**

DECLARATION

I declare that this thesis is my own work and has not been submitted in any form for another degree or diploma at any university or other institution of tertiary education. Information derived from the published or unpublished work of others has been acknowledged in the text and a list of references is given.

W M Darke
25 March 1991

ACKNOWLEDGEMENTS

Many people have given their time, understanding and expertise to enable me to convert an assortment of ideas, into the scientific research presented in this thesis. I hope that this work does justice to all of the people who have contributed to my project.

Thanks and appreciation to Dr. David Barnes and Dr. John Collins who have provided never-ending support, enthusiasm and encouragement. I consider myself to have been very fortunate in having such a complementary set of supervisors. Their guidance, wealth of knowledge and kindness has played a major role in the culmination of this work. A special thank you to David Barnes for his patience and dedication to the improvement of my writing skills, and to John Collins for his understanding of the difficulties associated with embarking on new research.

I was also very fortunate to have Barry Tobin tutor me in computers and computer programming when I first arrived at the Australian Institute of Marine Science (AIMS). I am especially grateful to Barry for relaying his expertise of computing and for his assistance and patience with computer problems encountered during this study. Thanks to Dr. Janice Lough for her helpful comments with many aspects of this research, but particularly for her advice and expertise on statistical matters associated with this work.

I have been extremely impressed with the outstanding level of technical support that Monty Devereux has given me with many of the experimental procedures performed in this study; particularly with the painstaking task of processing over 500 protein and chlorophyll samples. I am also especially grateful to Monty for the kindness and moral support he has shown me during the past three years. Jane Wu Won has also provided excellent assistance with experimental aspects of this work for which I am very grateful. I would also like to thank, the staff of the computer section at AIMS, Nick Harcock, Malcolm McKenzie, Bob McDonald and Coral

Graham, who have all provided help with computer problems. Monty and Jane, along with all of the other AIMS staff who have helped me with aspects of this research have never failed to impress me with their willing attitude to help and their dedication to their work.

There have been many people who have stepped in at various stages of this research and provided much needed and valuable contributions to the work; Dr. Bruce Chalker provided the necessary equations required for the chlorophyll determination, and very helpful comments on several parts of the research. Dr. Michel Pichon provided assistance with the difficult task of *Porites* species identification. In addition to Dr. Janice Lough, Dr. Glen De'arth, Dr. Ross Alford and Debbie Rae provided help and advise with statistical procedures used. Hua Wang helped me with the mathematical equations used for the computer models. Dr. John Chisholm and Dr. Jean-Pierre Gatusso have both provided very useful comments and criticisms relating to several aspects of this work. I am especially grateful to all of these people for the contributions they have made to this thesis.

I was very impressed with the excellent quality of photographic plates and figures presented in this thesis. Thanks to Karen Handley for producing the photographic plates and to Marietta Eden for helpful suggestions for improving and for drawing the figures. I would also like to thank Dr. Peter Moran for the frontispiece photograph and Dr. Peter Isdale for initiating the idea. Thanks also to Steve Clarke for arranging the text on the frontispiece.

I wish to thank the crews of the AIMS research vessels, R.V. *Lady Basten*, R.V. *Sirius*, R.V. *Pegasus* and especially the crew of the R.V. *Harry Messel* who have provided such a high standard of logistical support. I would also like to thank John Hardman of the AIMS marine operations unit for his help with supplying of equipment used for field work.

I wish to thank the Science and Engineering Research Council, U.K. for providing a 3 year PhD scholarship which has enabled me to undertake this research.

I am very grateful to Dr. Joe Baker, the Director of AIMS, for giving me the opportunity to carry out research at AIMS where I have been able to make full use of the excellent research facilities and expertise of the AIMS staff. I would also like thank Prof. Howard Choat, of the Marine Biology Department James Cook University, and the Science and Engineering Research Council for contributing to the cost of field trips and conferences I have been fortunate enough to attend.

Finally, there are many people who I would very much like to thank, who have cared about me, and have provided very important personal encouragement. These people have helped me to keep everything in perspective, so that I have enjoyed life and enjoyed doing my research. Very special thanks to my parents, family and friends back in England who have maintained close supportive links via correspondence. I would also especially like to thank Patricia Crowle, Pornsook Chongprasith and Kay Johnston for their friendship, kindness and invaluable personal support and encouragement, particularly when it was most needed. I wish to thank Chris Platt for his encouragement throughout this research and to thank Steve O'Reilly and Danielle Johnston for providing personal support and encouragement during the final stages of the thesis write-up.